PB86-166055

Survey of Research on Environmental Pollution Its Sources, Fate, Effects and Control, 1984

Alabama Univ., University

Prepared for

Environmental Protection Agency, Washington, DC

Mar 86

U.S. Department of Commerce
National Technical Information Service
NTIS

PB86-166055

EPA/600/8-86/009
March 1986

1984 SURVEY OF RESEARCH ON ENVIRONMENTAL POLLUTION - ITS SOURCES, FATE, EFFECTS AND CONTROL

A Report Prepared by The Environmental Research Committee of AIChE,
A Joint Committee of the AIChE Environmental Division
and the AIChE Research Committee

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This work was partially funded by the
U.S. Environmental Protection Agency

EPA Grant R811632-01-0

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BER Report No. 345-121

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WASHINGTON, DC 20460

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INFORMATION SERVICE
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SPRINGFIELD, VA. 22161

TECHNICAL REPORT DATA
(Please read Instructions on the reverse before completing)

1. REPORT NO. EPA/600/8-86/009	2.
3. RECIPIENT'S ACCESSION NO. PB86 166055/AS	
4. TITLE AND SUBTITLE 1984 SURVEY OF RESEARCH ON ENVIRONMENTAL POLLUTION-- ITS SOURCES, FATE, EFFECTS AND CONTROL	5. REPORT DATE March 1986 6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S) Irvin A. Jefcoat	8. PERFORMING ORGANIZATION REPORT NO. BER No. 345-121
9. PERFORMING ORGANIZATION NAME AND ADDRESS The University of Alabama Chemical Engineering Department University of Alabama	10. PROGRAM ELEMENT NO. D 109 11. CONTRACT/GRANT NO. R811632-01-0
12. SPONSORING AGENCY NAME AND ADDRESS Office of Environmental Engineering & Technology Office of Research and Development U.S. Environmental Protection Agency Washington, DC 20460	13. TYPE OF REPORT AND PERIOD COVERED Final Dec. 84 - Mar. 85 14. SPONSORING AGENCY CODE EPA/600/17
15. SUPPLEMENTARY NOTES Report prepared by the Environmental Research Committee of AIChE	

16. ABSTRACT

The Environmental Research Committee of the AIChE, a joint committee of the AIChE Environmental Division and of the AIChE Research Committee, conducted a survey of environmentally related research and/or design projects in progress at U.S. Colleges and Universities. Of interest was how the research effort had changed or shifted from a previous 1973 survey and what were the perceived environmental research and design needs of the respondents.

Based on the project information received, the identified research design needs submitted, and observations made from the survey the following conclusions were made:

- There has been a dramatic decrease in environmental research activity involving chemical engineering principles over the past decade as measured by the number of active projects reported.
- Pollution control technology is the area with the greatest perceived need and the greatest current effort.
- Water pollution control projects outnumber air pollution control projects by a factor of 2:1.
- The lowest emphasis is on legal and economic problems.
- Greater emphasis should be placed on chemical and biological effects and interactions, environmental modeling, pollutant detection, measurement and analytical methods.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group

18. DISTRIBUTION STATEMENT Release to Public	19. SECURITY CLASS *(This Report)* Unclassified	21. NO. OF PAGES 78
	20. SECURITY CLASS *(This page)* Unclassified	22. PRICE

EPA Form 2220-1 (Rev. 4-77) PREVIOUS EDITION IS OBSOLETE

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This document has been reviewed in accordance with U.S. Environmental Protection Agency policy and approved for publication. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

ACKNOWLEDGMENTS

This survey was conducted with the advice and assistance of the AIChE Environmental Research Committee. The members of this Committee and their AIChE affiliation is as follows:

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The survey received financial and/or in-kind support from the Environmental Division of AIChE, the Research Committee of AIChE, The University of Alabama, and the U. S. Environmental Protection Agency's Office for Research and Development (under Grant No. R811632-01-0).

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INTRODUCTION

The Environmental Research Committee of the AIChE, a joint committee of the AIChE Environmental Division and of the AIChE Research Committee, conducted a survey in 1973 of environmentally related research and/or design projects in progress at U.S. Colleges and Universities. Because of the large number of chemical engineers involved with and concerned about environmental projects, the Environmental Research Committee in 1983 decided to update the earlier survey and extend it to include industrial research. Of interest was how the research effort had changed or shifted from 1973 and what were the perceived environmental research and design needs of the respondents. A revised version of the 1973 questionnaire was mailed in December 1984, with the responses collected until March 1985. This report presents the results of the 1984 survey.

A separate appendix to this report containing the individual survey responses has been prepared for the U.S. EPA to make available through NTIS.

SURVEY METHOD

A survey by mail was chosen in 1973 and again in 1984 because of the time and expense of any other survey method. It was recognized that mail surveys have two major problems. One is the lack of two-way communication and the other is a limited or low response. To help offset these problems, limited telephone follow-up was used for the 1984 survey.

The Committee completely redrafted the 1973 questionnaire to reflect the recent changes in the AIChE Environmental Division from specific media to cross-cutting programs. Emphasis was placed on research by chemical engineers or research applying chemical engineering principles. A section was added on research and design needs. It was also recognized that other organizations had attempted to define environmental research needs (e.g., WPCF Wastewater Research Needs 1982). A packet was mailed to the Chemical Engineering Department Chairman at each of the 161 colleges and universities on the National AIChE mailing list. Each packet contained a cover letter explaining the purpose of the survey, a form for the university or college contact person, and a number of research project forms. Each investigator was asked to classify his research project using 12 categories. Copies of the packet are shown in the Appendix of this report.

A similar packet was mailed to 230 companies. The difference being that the packet mailed to industry separated the research and design needs from the project form. This was done to encourage practicing engineers to submit their perception of the research and design needs in

environmental pollution control when they could not, for one reason or another, submit project information. The list of companies was compiled from C&E News' top chemical companies and a list used in 1982 by the National AIChE office for a hazardous waste study. The packet was mailed to either the chief exe-utive officer, president, vice-president, an environmental affairs officer, or an AIChE Research Committee contact person. Copies of the packet are included in the Appendix to this report.

Before the survey mailings, a packet was sent to three universities and one company to test the questionnaire forms for any unforeseen difficulties. Each university had to be contacted by telephone whereas the company responded within two weeks with completed forms. No problems with the forms were uncovered. But, this test mailing did show the importance of personal contact. The industrial company contact had been aware of and supportive of the project.

In the event one of their members inquired of them about the survey, an information packet was sent to the American Petroleum Institute, National Agricultural Chemist's Association, National Petroleum Refiners Association, Chemical Manufacturer's Association, and the Dyes Environmental and Toxicological Organization. The purpose was to increase the industrial response.

SURVEY RESPONSE AND DISCUSSION

The colleges and universities responding to the 1984 survey are shown in Table 1, page 14, along with their responses. The complete list of colleges and universities receiving the survey forms is shown in Table A-1 in the Appendix. Follow-up telephone calls were made to 15 universities that received the forms. Of these, only one could complete the forms within the allowed time period.

Those schools responding with research project information are shown in Table 2, page 16, with their categorization of projects. From these tables, 58 of the 161 schools responded to the survey. Of these 58, 48 were engaged in 150 research projects. The 1973 survey questionnaire was mailed to 130 schools with 75 responding. Of these 75, only 44 had significant project activity with a total of 361 projects.

Although the number of schools responding with project information is about the same, there are significant differences between the above results for 1973 and 1984. The most obvious is the number of projects. The number of active environmentally related research projects reported in 1973 was more than twice the number reported in 1984. This decline in the number of projects could be attributed to sampling bias, a maturing of the environmental research effort, or limited availability of research monies from all sources. For example, the impact of newly enacted pollution control regulations in the early 1970's was significant in the 1973 survey. In responding to the need to limit emissions and effluents, industry sponsored a number of short term structured research projects. That short term demand is no longer evident in 1984.

Another significant difference is the population of schools responding. Only 14 of the 44 schools with projects in 1973 responded with projects in 1984. No Canadian schools responded in 1973 and 6 responded with projects in 1984. This could reflect a shift in interest or personnel, or both.

The complete list of companies to which the questionnaire was sent is shown in Table A-2 in the Appendix. Of the 230 companies contacted, 38 companies provided a written response with 11 of them involved in 33 research projects as shown in Table 3, page 18. The distribution of the industrial research projects by project category is shown in Table 4, page 19. A number of the packets (16) mailed to industry were returned unopened. In each case the CEO prior to 1984 had left the company. The first six returned like this were remailed to the current CEO; still, no response has been received. The low response from industry can be attributed to a number of reasons: (1) poor economic times, (2) lack of interest or understanding, (3) tired of so many questionnaires, (4) the "plain brown envelope" used to mail the packet, (5) the questionnaires did not reach the right people, (6) no environmental research projects, (7) a belief that there are no environmental research needs, (8) insufficient time to respond or respond fully, and many others. Some of these reasons are speculation, some from the responses, and some from telephone contact. Most often, it was a corporate policy not to participate in these types of activities.

The total number of research projects by project category is shown in Table 5, page 20. Pollution control technology is receiving the most effort with about 30% of the projects. No thermal or noise pollution control projects were reported. The split between water and air projects was about 2:1. This is the same ratio of effort reported in 1973.

Solid waste projects were about 9% of the effort in the 1973 survey results and 9% in 1984. Some investigators gave both water pollution control technology and solid waste treatment as the primary objective of their research, thus, there is some crossover between the water projects and the solid waste projects. Although only one category was used in compiling the statistics, an attempt was made to choose the category more closely aligned with the project based on the information provided.

The next major category of effort is Pollution Source Identification/Characterization with about 16%. This was not identified in the 1973 survey.

Category 9 - Chemical and Biological Effects and Interactions/-Environmental Modeling, is receiving the third largest effort with about 15%. The modeling aspect of this category is in agreement with the third major effort in the 1973 survey, while in 1973 chemical and biological effects were among those receiving the least effort. This shift is in agreement with the change in emphasis to specific pollutants and the generally held belief that there may not be a threshold for carcinogenic effects.

If Category 10 - Detection, Measurement and Analytical Methods, is combined with Category 12 - Other, then about 11% of the 1984 effort is in this area. The Other category is mainly physical/chemical property data. In the 1973 survey, the topics of these two categories were considered together. With this combination the ranking of this effort is in agreement with the 1973 results.

In 1973, legal, economic, and health aspects were receiving the least emphasis. In 1984, this still holds true for the legal and economic categories (6 and 7). This is somewhat surprising based on the emphasis placed on economics in chemical engineering curricula.

However, this may be due to the perspective of those completing the forms rather than an accurate reflection of budgeted efforts.

Inadvertently, the project form mailed to the universities was missing Category 11 - Global Environmental Problems such as the CO_2 Greenhouse Effect or Acid Rain. Even with this omission it was still surprising that only one project was identified as having its major objective directly dealing with the acid rain problem. Certainly, those projects involved in the control of SO_X and NO_X are related to acid rain, even if the control of acid rain was not their primary objective. It could be that either acid rain research efforts do not involve chemical engineers and chemical engineering principles, those involved in this research did not respond to the questionnaire, or very little is being done on this topic. Most probably it was a lack of response.

The environmental process design needs and the environmental research needs identified by the 1984 survey respondents are shown in Tables 6 and 7, pages 21 and 33, respectively. The needs were taken verbatim from the information submitted by each respondent, therefore, duplicate entries reflect more than one respondent advocating that need. In the areas of most reported activity (categories 1, 2, and 3) industry respondents identified as many or more design needs as did the university respondents. University respondents identified far more research needs than did industry respondents in most categories. These needs have been grouped according to the categories used for projects and a summary is given in Table 8, page 48. This was a subjective judgment of the Committee and may not accurately reflect the choice that the respondent would have made. In most cases the needs were categorized according to the respondent's primary and secondary categories for his project. The one deviation from this was that needs dealing with

models were classed in Category 9 - Chemical and Biological Effects and Interactions/Environmental Modeling.

The ranking given by the percentage response for the top four research and design needs shown in Table 8 are: (1) Category 2 - Pollution Control Technology, 33%, (2) Category 9 - Chemical and Biological Effects/Modeling, 22%, (3) Category 10 - Measurement Methods, 15%, and (4) Category 3 - Solid Waste, 11%. This ranking is in agreement with that based on the percentage of the project activity efforts reported in the 1973 and 1984 surveys. Thus, the relative importance and interest in these categories has remained about the same over the past decade.

No industrial respondent identified a need in Category 6 - Economic Impacts and Cost Analyses of Pollution/Pollution Control. This resulted in the lowest ranking for economic studies, which was preceded by Category 8 - Strategies, Category 1 - Pollution Source, Category 11 - Global, and Category 7 - Legal. All of these five categories combined had less than 6% of the identified needs.

A comparison of the active projects with the identified research and design needs is given in Table 9, page 49. The match between project effort and perceived needs is fairly good for most of the categories as shown in Figure 1, page 13. Notable exceptions are in Categories 1, 9, and 10. In Category 1, the project effort far exceeds the perceived needs. This suggests that the major sources of pollution have been addressed and characterized or they are in progress. A greater effort is suggested for Categories 9 and 10 (effects, modeling, and measurement) which is consistent with the definition of ultimate impact of emissions and effluents on the environment in general and people specifically.

Table 10, page 50, contains a comparison of the 1973 reported project funding for universities with the university reported project funding for 1984. The total project funding of $16 million is the same for both surveys. When the number of active projects reported in each survey is considered with the inflation rate, the average cost for an environmental research project has remained about the same (in 1984 dollars, about $100K/project).

The breakdown of the funding sources for the 1984 survey was: $12 million from government agencies, $2 million from industrial sources, $1 million from the universities, and $1 million from other sources. Of the $12 million from government agencies, $4 million was from EPA. Thus EPA is providing 30% of the funds from government sources for environmental research reported in the 1984 survey or 25% of the total reported funds.

LIMITATIONS

The use of the results of the 1984 Environmental Research Survey presented in this report should be made with caution. The low project response from industry makes the use of this information qualitative at best. Many schools and industries known to be engaged in environmental research failed to respond; therefore, their input is missing. The groupings of the research and design needs were made by the Committee and may not accurately reflect the respondent's choice or intention.

CONCLUSIONS

Based on the project information received, the identified research and design needs submitted, and observations made during this study, the following conclusions have been made:

- There has been a dramatic decrease in environmental research activity involving chemical engineering principles over the past decade as measured by the number of active projects reported.

- Pollution control technology is the area with the greatest perceived need and the greatest current effort.

- Water pollution control projects outnumber air pollution control projects by a factor of 2:1.

- The lowest emphasis is on legal and economic problems.

- Greater emphasis should be placed on chemical and biological effects and interactions, environmental modeling, pollutant detection, measurement and analytical methods.

RECOMMENDATIONS FOR FUTURE SURVEYS

Based on the results obtained in the 1973 survey and the 1984 survey, the following recommendations for future surveys of this type are made:

- A special effort should be made to obtain a larger response for environmental research and design needs from those active in plant design, operation and maintenance. The people involved in these areas may not be involved in research and may not be aware of the survey without a special effort.

- The data gathering approach for this type of data could be improved by starting from existing data bases (e.g., EPA, DOE, DOD, and SSIE) of ongoing research and then use these data to select candidate schools and companies for the follow-up survey. This would result in the survey being a validating tool for the data gleaned from the funding agency lists.

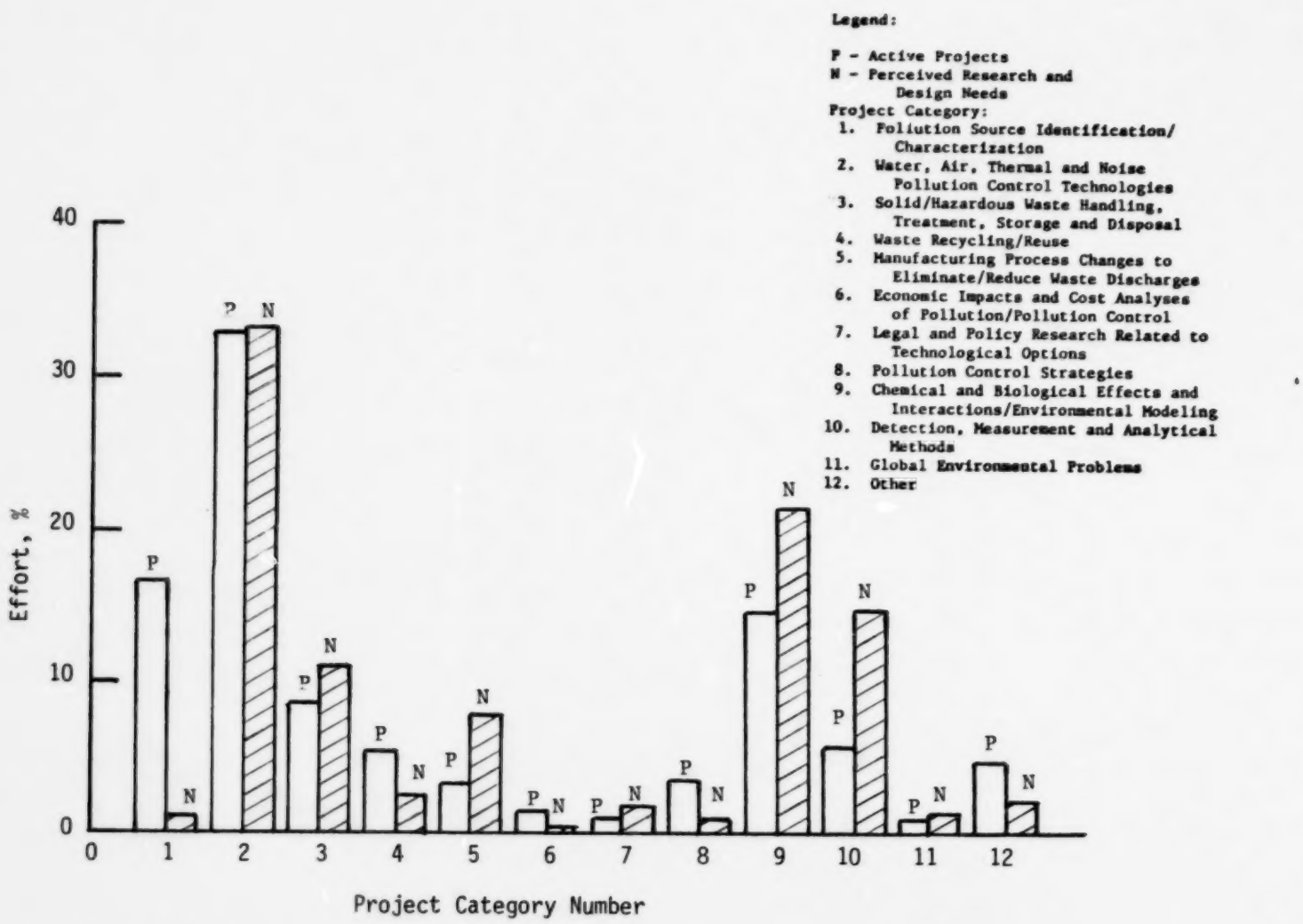
Legend:
P - Active Projects
N - Perceived Research and Design Needs
Project Category:
1. Poliution Source Identification/ Characterization
2. Water, Air, Thermal and Noise Pollution Control Technologies
3. Solid/Hazardous Waste Handling, Treatment, Storage and Disposal
4. Waste Recycling/Reuse
5. Manufacturing Process Changes to Eliminate/Reduce Waste Discharges
6. Economic Impacts and Cost Analyses of Pollution/Pollution Control
7. Legal and Policy Research Related to Technological Options
8. Pollution Control Strategies
9. Chemical and Biological Effects and Interactions/Environmental Modeling
10. Detection, Measurement and Analytical Methods
11. Global Environmental Problems
12. Other
Effort, %
40
30
20
10
0
0 1 2 3 4 5 6 7 8 9 10 11 12
Project Category Number

Figure 1. Percentage Distribution of Effort for Active Projects and Perceived Needs by Project Category.

Table 1. Universities Responding to the 1984 Survey of Research on Environmental Pollution - Its Sources, Fate, Effects and Control

University	Response
University of Akron	1 Project
University of Alabama	1 Project
University of Alberta	1 Project
University of Arizona	2 Projects
Auburn University	No Current Projects
University of Calgary	1 Project
University of California/Berkeley	3 Projects
California Institute of Technology	No Current Projects
Clemson University	No Current Projects
Cleveland State University	2 Projects
University of Colorado	No Current Projects
Colorado State University	18 Projects
University of Connecticut	1 Project
Cornell University	3 Projects
University of Florida	3 Projects
Georgia Institute of Technology	2 Projects
University of Idaho	1 Project
University of Iowa	1 Project
Kansas State University	1 Project
University of Kentucky	6 Projects
Lafayette College	No Current Projects
Laval University	1 Project
Louisiana State University	11 Projects
Louisville Speed Scientific School	3 Projects
McGill University	4 Projects
McMaster University	4 Projects
University of Massachusetts	6 Projects
Michigan State University	1 Project
Michigan Technological Univ.	7 Project
Mississippi State University	No Current Projects
University of Missouri/Columbia	4 Projects
Montana State University	1 Project
University of Nebraska	No Current Projects
University of New Brunswick	1 Project
New Jersey Inst. of Tech.	6 Projects
University of Notre Dame	1 Project
Ohio State University	6 Projects
Ohio University	2 Projects
Oklahoma State University	3 Projects
The Inst. of Paper Chemistry	1 Project
Pennsylvania State University	2 Projects

Table 1. Continued

University	Response
University of Pittsburgh	1 Project
Princeton University	2 Projects
Purdue University	8 Projects
University of Rochester	2 Projects
Rose-Hulman Inst. of Technology	No Current Projects
Rutgers-The State University	10 Projects
Syracuse University	Will Respond Later
Texas Tech University	4 Projects
University of Toledo	2 Projects
University of Toronto	3 Projects
University of Tulsa	1 Project
University of Utah	1 Project
University of Washington/Seattle	1 Project
Washington State University/Pullman	1 Project
Washington University/St. Louis	No Current Projects
Wayne State University	2 Projects
University of Western Ontario	1 Project

Table 2. Distribution of University Projects By Project Category

University	Project Categories*											
	1	2	3	4	5	6	7	8	9	10	11	12
Akron		1										
Alabama									1			
Alberta									1			
Arizona		2										
Calgary												1
California/Berkely		1			2							
Cleveland State		2										
Colorado State	9					1	1	1	3	2		2
Connecticut		1										
Cornell		2							1			
Florida				2					1			
Georgia Tech	1									1		
Idaho										1		
Iowa									1			
Kansas State		1										
Kentucky		3		2				1				
Laval		2										
Louisiana State	3	2	3						1	1		
Louisville Speed Sci.		2						1				
McGill University	1							1	2			
McMaster University		3							1			
Massachusetts		3							1	1		1
Michigan State								1				
Michigan Tech.	2	3						1	1			
Missouri/Columbia		1		1	2							
Montana State									1			
New Brunswick									1			
New Jersey Tech.	1	1	2							2		
Notre Dame											1	
Ohio State	1	3								2		
Ohio							1		1			
Oklahoma State	1		1						1			
Inst. Paper Chemistry									1			
Pennsylvania State		2										
Pittsburgh		1										
Princeton	1	1										
Purdue	1	5				1						1
Rochester	2											
Rutgers/State	2	1	2					1	4			

*

Table 2. Continued

University	Project Categories*											
	1	2	3	4	5	6	7	8	9	10	11	12
Texas Tech	2		1								1	
Toledo	1	1										
Toronto			1		1				1			
Tulsa				1								
Utah		1										
Washington									1			
Washington State									1			
Wayne State	2											
Western Ontario									1			

*1. Pollution source identification/characterization
2. Water, air, thermal and noise pollution control technologies
3. Solid/hazardous waste handling, treatment, storage and disposal
4. Waste recycling/reuse
5. Manufacturing process changes to eliminate/reduce waste discharges
6. Economic impacts and cost analyses of pollution/pollution control
7. Legal and policy research related to technological options
8. Pollution control strategies (e.g. in different media and different environments)
9. Chemical and biological effects and interactions/environmental modeling
10. Detection, measurement and analytical methods
11. Global environmental problems such as the CO_2 greenhouse effect or acid rain
12. Other

Table 3. Companies Responding to the 1984 Survey of Research on Environmental Pollution - Its Sources, Fate, Effects and Control

Industry	Response
Air Products & Chemicals, Inc.	Research & Design Needs
Allied Chemical Company	Research & Design Needs
American Brands	Declined to Participate
American Home Products Corp.	Declined to Participate
Amoco	Research & Design Needs
ASARCO, Inc.	Research & Design Needs
Badgers Engineers Inc.	1 Project
The Boeing Company	6 Projects
Bristol-Myers Company	No Current Projects
Carus Chemical	2 Projects
Champion International Corporation	No Current Projects
Cosden Oil & Chemical Company	No Current Projects
Crompton & Knowles	Research & Design Needs
Dow Chemical Company	Research & Design Needs
Dundee Cement Company	No Research Activity
E. I. DuPont de Nemours & Company	Declined to Participate
El Paso Natural Gas Company	No Research Activity
Emmart Corporation	No Current Projects
Ethyl Corporation	No Current Projects
Fluor Power Service Corporation	6 Projects
Gas Research Institute	Research & Design Needs
W. R. Grace & Co.	Declined to Participate
Great Lakes Chemical Corporation	Research & Design Needs
Hercules Incorporated	1 Project
Inland Steel Company	6 Projects
Marathon Petroleum	No Current Projects
Mobil Oil Company (Res. & Dev.)	Research & Design Needs
Monsanto Company	4 Projects
Occidental Chemical Corporation	2 Projects
Olin Corporation	2 Projects
Ralph M. Parsons Corporation	No Current Projects
Phillips Chemical Company	No Research Activity
Schering-Plough Company	Research & Design Needs
Shell Development Company	3 Projects
Stauffer Chemical Co.	No Current Projects
Texaco	Telephone Response
Waste Management, Inc.	2 Projects
Zimpro Inc.	Declined to Participate

Table 4. Distribution of Industrial Projects By Project Category

	Project Categories*											
Industry	1	2	3	4	5	6	7	8	9	10	11	12
Badger Engineers, Inc.		1										
The Boeing Company		3		1	1					1		
Carus Chemical		2										
Fluor Power Service Corp.		1	3				1					
Hercules Incorporated		1										
Inland Steel Company	1	3		1								
Monsanto Company												4
Occidental Chemical Corp.		2										
Olin Corporation				2								
Shell Development Company		2	1									
Waste Management, Inc.			2									

*1. Pollution source identification/characterization
2. Water, air, thermal and noise pollution control technologies
3. Solid/hazardous waste handling, treatment, storage and disposal
4. Waste recycling/reuse
5. Manufacturing process changes to eliminate/reduce waste discharges
6. Economic impacts and cost analyses of pollution/pollution control
7. Legal and policy research related to technological options
8. Pollution control strategies (e.g. in different media & different environments)
9. Chemical and biological effects and interactions/environmental modeling
10. Detection, measurement and analytical methods
11. Global environmental problems such as the CO_2 greenhouse effect or acid rain
12. Other

Table 5. Total Number of Research Projects
By Project Categories

Project Category	Industry (no. projects)	University (no. projects)	Total	%
1. Pollution source identification/ characterization	1	29	30	16.4
2. Water, air, thermal, and noise pollution control technologies	15	45	60	32.8
3. Solid/hazardous waste handling, treatment, storage and disposal	6	10	16	8.7
4. Waste recycling/reuse	4	6	10	5.4
5. Manufacturing process changes to eliminate/reduce waste discharges	1	5	6	3.3
6. Economic impacts and cost analyses of pollution/pollution control	0	3	3	1.6
7. Legal and policy research related to technological options	1	1	2	1.1
8. Pollution control strategies (e.g. in different media and different environments)	0	7	7	3.8
9. Chemical and biological effects and interactions/environmental modeling	0	27	27	14.7
10. Detection, measurement and analytical methods	1	10	11	6.0
11. Global environmental problems such as the CO_2 greenhouse effect or acid rain	0	2	2	1.1
12. Other	4	5	9	4.9
			183	99.8%

Table 6. Environmental Process Design Needs Identified by 1984 Survey Respondents

MOST IMPORTANT (1)

Category 1. Pollution source identification/characterization

University	Industry
None	None

Category 2. Water, air, thermal and noise pollution control technologies

University	Industry
Adsorption	Clean up central sources of air pollution such as power generation facilities and petroleum refineries (including removal of impurities from refined products)
Adsorber design	Economically efficient process for the effective treatment of wastes
Mixed solute adsorber design model (non-linear)	Plating wastewater treatment sludge, Inexpensive low concentration heavy metals recovery
Ozone absorber/reaction	Biological reactors
Collection of submicron aerosols	Anaerobic processes-ind. WWT
Design of optimal spray devices	Treatment of domestic sewage
Emission control at source	Flue gas treating process with no waste products
Effective, reliable, economic scrubbers	
Fixed film processes	
Economical SO_2 removal at source	
Processes for destruction/organic wastes in aqueous streams	
Fluidization in biological wastewater treatment	
Gas-liquid injector design	
CSTR scale up	
Design of biological wastewater treatment plants	
$SO_2 + NO_x$ removal from coal combustion	
Biologically active "flow-thru" scrubbers	
Mixing of small jets in crossflow applications	
Automation of wastewater treatment systems	

Table 6. Process Design Needs Continued

Category 2. Water, air, thermal and noise pollution control technologies (Continued)

University	Industry
Effective gas scrubbing to remove air pollutants (organics, SO_2, NO_x)	
Air flotation systems	
Ammonia control	
Better adsorbents for drinking water treatment	
Combustion modification for pollutant control	

Category 3. Solid/hazardous waste handling, treatment, storage and disposal

University	Industry
Solids dewatering equipment	Incineration of hazardous wastes
Improved incinerators	Incineration
Processes for decontaminating leachates and groundwater	Fluidized bed combustion of petroleum refinery hazardous wastes
	Pressurized and atmospheric fluid bed combustion
	Hazardous waste landfill (double liner)
	Groundwater protection, containment and cleanup systems (Superfund,RCRA)
	Groundwater decontamination

Category 4. Waste recycling/reuse

University	Industry
Resource recovery/Process	Economic heavy metal recovery from electroplating solution and treatment sludges
Resource recovery	

Table 6. Process Design Needs Continued

Category 5. Manufacturing process cnanges to eliminate/reduce waste discharges

University	Industry
Waste concentration/Material recovery	Manufacturing process changes to eliminate, reduce, or reuse environmentally undesirable waste discnarges
Segregation of waste streams at source	Minimize production of health-related pollutants
Reduction of wastes generation at source	Improved separations to reduce waste streams
An integrated coal management policy	Coal cleaning
Alternative methods of pulp bleaching	Development of continuous coking or non-recovery coking

Category 6. Economic impacts and cost analyses of pollution/pollution control

University	Industry
None	None

Category 7. Legal and policy research related to technological options

University	Industry
None	None

Category 8. Pollution and control strategies (e.g. in different media and different environments)

University	Industry
None	None

Table 6. Process Design Needs Continued

Category 9. Chemical and biological effects and interactions/environmental modeling

University	Industry
Modeling software products	None
Predictive model of chemical conditioning	
Broader understanding/Biochem kinetics	
Better ecosystem conceptual models	

Category 10. Detection, measurement and analytical methods

University	Industry
Better process analysis	None
Quantitative analysis	
Better analytical control	
Improved monitoring of pollutants in the unsaturated zone	
Glasses with fewer, smaller surface defects	
On-line bio indicators of effluent quality	

Category 11. Global environmental problems such as the CO_2 greenhouse effect or acid rain

University	Industry
None	None

Category 12. Other

University	Industry
Effective technology transfer to plant operators	Definition of physical properties
	Physical properties of multicomponent electrolyte solutions

Table 6. Process Design Needs Continued

SECOND IMPORTANT (2)

Category 1. Pollution source identification/characterization

University	Industry
None	None

Category 2. Water, air, thermal and noise pollution/pollution control

University	Industry
Draft tube design	Flexible modular waste treatment systems for low level flow effluent streams
Sensor feedback & computer interfacing in wastewater treatment	Solvent and water inexpensive low concentration separation and or recovery
Better mixing, flocculation, sedimentation, filtration combinations for drinking water treatment	Mobile waste treatment units (Incin., solvent recovery, phys. or chem.)
Effective ground water cleaning methods	More cost effective boiler design for SO_2/NO_x removal with minimum by-product formation (acid rain)
Heavy metal toxics control	SO_2 & NO_x removal from stack gases
Air stripping	Stack scrubbing SO_2 & NO_x
Aeration scale up	More efficient SO_x reduction process in fluid catalytic cracking operations
Design of pnysical-chem. processes for wastewater treatment	Granular carbon contact column mechanical design
Atomic weight graded separation membranes	Groundwater treatment & reclamation
Effective, reliable, economic removal of SO_2 from stack gases	High rate anaerobic digestion
Immobilization of enzymes on "flow-thru" columns	

Table 6. Process Design Needs Continued

Category 3. Solid/hazardous waste handling, treatment, storage and disposal

University	Industry
Incineration	In-situ treatment for persistent organics
Incineration of chlorinated hydrocarbons	In-situ treatment for landfills
Fluidized-bed reactor design for incineration or pyrolysis	Chemical destruction of hazardous wastes
Processes for effectively incinerating refuse	
Design of underground disposal	
Prediction of boiler thermal performance	

Category 4. Waste recycling/reuse

University	Industry
Improvements in recycling of paper	Improved selectivity and recovery techniques in mineral beneficiation
Promotion of recovery and recycling	
Minimization of water and solvent use	

Category 5. Manufacturing process changes to eliminate/reduce waste discharges

University	Industry
Manufacturing process changes to reduce pollution load	Low-cost photovoltaic
Improved processes to reduce hazardous by-products	Improved technologies for production and utilization of energy resources
Closed loop systems	Hot connecting mills & thin slab continuous casting
Solvent substitution	

Table 6. Process Design Needs Continued

Category 6. Economic impacts and cost analyses of pollution/pollution control

University	Industry
None	None

Category 7. Legal and policy research related to technological options

University	Industry
None	None

Category 8. Pollution and control strategies (e.g. in different media and different environments)

University	Industry
None	None

Category 9. Chemical and biological effects and interactions/environmental modeling

University	Industry
Predictive methods in describing multicomponent migration in groundwater and porous media Interaction between filter media, disinfectant and bacteria in filters Mixed microbial population rate constants	None

Table 6. Process Design Needs Continued

Category 10. Detection, measurement and analytical methods

University	Industry
Optimal design of collectors	Fail safe annulus monitor for injection wells
Faster analytical control	
Control systems--DO,pH	
Better detection devices	
Detection of trace organics in gases	
Improved bending methods for curved mirrors	
Vertical integration of data transfer for quality assurance	

Category 11. Global environmental problems such as the CO_2 greenhouse effect or acid rain

University	Industry
None	None

Category 12. Other

University	Industry
None	Thermodynamic data & prediction correlations
	Definition of reliable estimating protocols for phys. properties

Table 6. Process Design Needs Continued

THIRD IMPORTANT (3)

Category 1. Pollution source identification/characterization

University	Industry
None	None

Category 2. Water, air, thermal and noise pollution control technologies

University	Industry
Enzyme technology for wastewater treatment	Improvements to biological treatmemt systems for toxics removal
Effective surface water cleaning methods	Advanced wastewater treatment-biophysical
Novel methods for removal of trace organics	Control of hydrocarbon fugitive emissions
Device for biofilm control	Cost effective devices to remove fine particles (respirable particulates) in flue gases
Fluidized-bed bioreactor design	Air emission control devices which generate a minimum of secondary waste
Mixing scale up	Improved process emission control systems
Mixed solute interactions in membrane separations	Improved heater/boiler design for more efficient combustion and NO_x reduction
	Cyanide and metal removal processes

Table 6. Process Design Needs Continued

Category 3. Solid/hazardous waste handling, treatment, storage and disposal

University	Industry
Alternative treatment methods	Cost effective technologies for destroying hazardous wastes/contaminants or essentially rendering them environmentally benign
Solid waste immobilization	Processes to render innocuous environmentally-objectional constituents of solid wastes
Organic toxics control	Improved process design for capture/destruction of gaseous emissions and leachate from hazardous waste, treatment, storage and disposal facilities (RCRA)
Spill prevention	Universal leachate test for solid waste
Oxidation processes	Fluid bed incinerator for solid & liquid wastes
Better primary & secondary liner systems for hazardous waste containment sites	Incineration
Processes for effectively incinerating wastewater treatment sludge	

Category 4. Waste recycling/reuse

University	Industry
None	None

Category 5. Manufacturing process changes to eliminate/reduce waste discharges

University	Industry
Process substitution	Iron production without use of coke
Sludge dewatering	
Computer aided design	

Table 6. Process Design Needs Continued

Category 6. Economic impacts and cost analyses of pollution/pollution control

University	Industry
Cost estimating of collection systems	None

Category 7. Legal and policy research related to tecnnological options

University	Industry
None	None

Category 8. Pollution and control strategies (e.g. in different media and different environments)

University	Industry
Better control strategies	None

Category 9. Chemical and biological effects and interactions/environmental modeling

University	Industry
Total environmental simulation for control strategies	Reaction kinetic data for multicomponent inorganic systems Definition of fate kinetic parameters (biochemical, photodegradation, etc.)

Category 10. Detection, measurement and analytical methods

University	Industry
Remote sensing Continuous multicompound monitoring for industrial waste streams	None

Table 6. Process Design Needs Continued

Category 11. Global environmental problems such as the CO_2 greenhouse effect or acid rain

University	Industry
None	Acid rain reduction through emission control or fuel cleaning

Category 12. Other

University	Industry
None	None

Table 7. Environmental Research Needs Identified by 1984 Survey Respondents

MOST IMPORTANT (1)

Category 1. Pollution source identification/characterization

University	Industry
Identifying sources for products of incomplete combustion	None

Category 2. Water, air, thermal and noise pollution control technologies

University	Industry
Aerobic treatment of wastewater	Clean coal combustion
Ozonalysis	Oil/wastewater emulsion breaking
Non-point source pollution control	Indoor air pollution
Adsorption Theory and Practice	Genetic engineering for pollution control
Particle separation from liquids	Wastewater handling and disposal
Removal of volatile syntnetic organic chem. from drinking water	Groundwater protection & reclamation
Destruction of hazardous cmpds. in underground water supplies	Anaerobic processes
Trace organic and fine particulate separation technology	Insitu groundwater contamination remediation
Functional test for catalytic converter	
Flame and spray aerodynamics	
Increase the efficiency of FGD by using effective sorbents	
Prediction of necessary & sufficient precursor conditions	
Indoor air pollution	
Sulfolobus optimization	
Immobilized biofilm control	
Turbulent entrainment across stratified fluids	
Improved aerosol collection	
Polymeric surfactants	

Table 7. Research Needs Continued

Category 3. Solid/hazardous waste handling, treatment, storage and disposal

University	Industry
Biological treatment of hazardous waste	Solid/hazardous waste treatment/disposal
Biological treatment of toxic wastes	Incineration of brominated organics and inorganics
Control of hazardous pollutants	Insitu soil and groundwater detoxification, monitoring, modeling, and analytical methods
Control of hazardous wastes	Cost effectiveness techniques to clean up soil/ground water (insitu, biodegradation, etc.)
Hazardous waste handling & disposal	Insitu treatment in soils and sediments
Genetics of microbes for biodegradation of hazardous compounds	
Flame mode kinetics of wastes	
Basic combustion chemistry-reactions, mechanisms, rate coefficients	

Category 4. Waste recycling/reuse

University	Industry
Devise regeneration strategies for recovering metal cyanide complexes from appropriate ion exchange resins	Waste recycling & stabilization technology

Category 5. Manufacturing process changes to eliminate/reduce waste discharges

University	Industry
Solids dewatering	Non-chromated metallic corrosion inhibitors
More efficient designs for biomass fuel use	

Category 6. Economic impacts and cost analyses of pollution/pollution control

University	Industry
None	None

Table 7. Research Needs Continued

Category 7. Legal and policy research related to tecnnological options

University	Industry
Reliable ppt/ppb standards	None

Category 8. Pollution control strategies (e.g. in different media and different environments)

University	Industry
None	None

Category 9. Chemical and biological effects and interactions/environmental modeling

University	Industry
Movement of water and solutes in the vadose zone	Study of health effects of pollutants
Transport phencmena	Determination if a cnemical is a human carcinogen
Transport phenomenon in packed beds	Low level pollutant effects and synergism
Improvement of atmospheric transport models	Photodegradation of specific cnemicals
Monte Carlo modelling of Atmos. transport	Improvement of predictive techniques used in source proportioning and dispersion modeling
Mass transport plus reaction	
Prediction of polar organics separation by membranes	
Mass transfer & dispersion in natural waters and aquifers	
Gas phase adsorption with activated carbon	
Effects of water on adsorption of organics on activated carbon in gas phase	
Chemical interactions with soils and sediments	
Waste/groundwater/soil chemistry	
Diffusion of gases in porous solids (eg SO_2 in lime)	
Sediment-water interactions	
Toxicant chemistry in porous media	
Formulation of solute-solid interactions in complex chemical/ mineralogical systems	

Table 7. Research Needs Continued

Category 9 Chemical and biological effects and interactions/environmental modeling (Continued)

University	Industry
Biodegredation of chlorinated aromatics	
Basic chemical kinetics of reactions of chlorinated hydrocarbons	
Chemical kinetics of atmospheric free radicals	
Ozone formation kinetics	
Dissolution kinetics of solid phases	
Kinetics of radionuclides in environmental systems	
Biochemical reaction kinetics	
Mixing and reaction in plumes	
Effects of particles in plume	
Reaction of pollutants with aquatic surfaces	
Factors affecting metal solubilization	
Model validation	
Comparisons between field measurements and model	
Toxic properties	
Toxicity & inhibition	
Better understanding of interaction of engineering parameters with living cells	
Sublethal effects on wildlife	
Accurate estimates of atmosphere's ability to disperse pollution	
Determination of reaction products and pathways	
Cell surface chemistry	
Mesometeorology	
An improved numerical solution method	
Behavior of multicomponent electrolytes-activity	
Gas particle and atmospheric-ice interactions	
Land-sea breezes	

Table 7. Research Needs Continued

Category 10. Detection, measurement and analytical methods

University	Industry
Anaerobic reactor-process monitoring	Develop reliable analytical measurement for pollutants
Distinction of inorganic Al from organic -Al in soil solutions	
Speciation of metal in pollutants	
Analytical chemical and physical separations	
New satellite remote sensing technology	
Remote/automatic precipitation measurement	
Overland flow measurements	
Remote flow sensing	
Remote sensing and size anal. of particles	
Instrumental methods for complex analyses	
Trace organics analysis	
Isotopic analysis	
Analytical methodology	
Development of more sensitive analytical techniques	
VOC emission/estimation and control	
Measurement of dry deposition	

Category 11. Global environmental problems such as the CO_2 greenhouse effect or acid rain

University	Industry
None	None

Category 12. Other

University	Industry
Devise consistent, accurate database	None
Integrated information systems	
Longterm ecosystem databases	
Reduction of theory to practice for plant operators	

Table 7. Research Needs Continued

SECOND IMPORTANT (2)

Category 1. Pollution source identification/characterization

University	Industry
Waste characterization-loading and content	None
Biological indicators of pollution	

Category 2. Water, air, thermal and noise pollution control technologies

University	Industry
Mass transfer	Enhanced biological degradation of priority pollutants
Mass transfer to droplets	Biochemical oxidation/reduction of specific chemicals
Anaerobic treatment of wastewater	Economical trace organic removal from wastewater
Control strategy for anaerobic digestion	Improved air pollution control techmology emission suppression vs. capture & removal
Sulfolobus characterization	Contaminated groundwater treatment & retrieval
Investigate other factors that might affect FGD	Fate and effects of contamination in groundwater
Biodegradation of isosaccharinic acids	Drinking water purification
Kinetic interactions of mixed microbial populations	Granular carbon contact column-mech. design
Nutrient effects of effluents	
Scale effects on dense gas behaviors	
Gas-particle conversion	
Fluidized bed nydrodynamics & particle shear	
Multicomponent description of adsorption in an unknown background	
Oxygen transfer	
Relation between sorbent composition and reactivity to SO_2	
Colloid chemistry	
Sludge disposal & dewatering	

Table 7. Research Needs Continued

Category 2 Water, air, thermal and noise pollution control technologies (Continued)

University	Industry
Thermochemical treatment of toxic wastes	
Thermodynamics of hydrocarbons and radicals	
Material recovery by membranes/selective adsorption	
Improved process control	
Improved process control	
Process control	
Sulfur removal from fuels	
Modeling glass strength/hardness as a function of surface topology	
Trace metals during combustion	

Category 3. Solid/hazardous waste handling, treatment, storage and disposal

University	Industry
Sludge disposal & dewatering	Toxic hazardous waste destruction
Hazardous waste containment	Chemical destruction/stabilization of hazardous waste
Hazardous waste treatment	Microbiological detoxification of soils
Detoxification	
Thermochemical treatment of toxic wastes	
Thermodynamics of hydrocarbons and radicals	
Hazardous waste containment	
Hazardous waste treatment	
Detoxification	

Category 4. Waste recycling/reuse

University	Industry
Material recovery by membranes/selective adsorption	Municipal sludge disposal/reuse

Category 5. Manufacturing process changes to eliminate/reduce waste discharges

University	Industry
Improved process control (twice) Process control Modelling glass strength/hardness as a function of surface topology	Elimination of process wastes

Category 6. Economic impacts and cost analyses of pollution/pollution control

University	Industry
Incorporate risk analysis and real cost	None

Category 7. Legal and policy research related to technological options

University	Industry
Interactive expert systems	Improvement in methodology for determining future hazards of specific substances Risk assessment and mangement Develop standards to determine tolerable impact levels

Category 8. Pollution control strategies (e.g. in different media and different environments)

University	Industry
Satellite identification Seepage analysis & control methodologies w/ very long term reliability Sludge management options	Cost effective techniques to desulfurize, denitrify, demetallize heavy feeds/coal

Table 7. Research Needs Continued

Category 9. Chemical and biological effects and interactions/ environmental modeling

University	Industry
Realistic modeling of droplet combustion process	Develop reliable physical property data
Evaluation of the efficacy of lagrangian models simulations	Toxicity impact of landfilled treatment plant sludges
Determination of candidate products of incomplete combustion	
Mixing and reaction in underground flow	
Subsurface transport of organic pollutants	
Groundwater migration of non-aqueous liquids	
Atmospheric transport modelling	
Interfacial transport (air/sea/land interface)	
Disposal of toxic wastes and their eventual integration into natural water & air	
Toxicant-plant-porous media interaction and patnways	
Adequate ecosystem models to predict effects	
Interactive simulation model	
Parameter estimation	
Chemical and biological evaluations of deleterous cmpds.	
Impact of macropores on water movement through soils	
Isotherm data for multicomponent gas phase adsorptions	
Modeling of adsorption processes with computer	
Chemical adsorption theory	
Determination of microbial population dynamics	
Dispersion in buoyant boundary layers	
Mixed layer interactions	
Longterm monitoring of effects on wildlife	
Speciation of metal in the body (blood urine-sweat)	

Table 7. Research Needs Continued

Category 10. Detection, measurement and analytical methods

University	Industry
Remote sensing from satellites	Detection, measurement and analytical techniques
Detection/quantification of ozone	
Improvement in radiochemistry and detection methods	
Reliable and more accurate determination of bacteriological quality evaluation	
Inexpensive analytical instrumentation	
Multielement analysis	
Cost effective analytical instrumentation	
Analysis techniques for low level contaminants	
Representativeness of mountain observation to the free atmosphere	
Chemical stability of fly ash determination	
Measurement of OH free radicals	
Instrumental analysis for wastewater contaminants	
Toxicity testing	
Measurement of atomizer droplet emission spectrum	
Remote sizing of liquid aerosols	
Better sulfur gas detectability	

Category 11. Global environmental problems such as the CO_2 greenhouse effect or acid rain

University	Industry
None	None

Category 12. Other

University	Industry
Structure and dissociation of organic molecules	None

Table 7. Research Needs Continued

THIRD IMPORTANT (3)

Category 1. Pollution source identification/characterization

University	Industry
None	Improvement in methods to assess general environmental hazards Improved methods to determine public exposure to pollutants-source/receptor relationships

Category 2. Water, air, thermal and noise pollution control technologies

University	Industry
Aquatic chemistry Design of biologically specific probes-bioindicators Advances in bioprocessing Continuous flow steam stripping Determination of nutrient requirements Adsorption of mixed solutes on natural & synthetic substrates Kinetics of water vapor adsorption/desorption on retorted oil shale Scale effects on water spray Regeneration of activated carbon Nutritional aspects of anaerobes Removal of inorganic dissolved solids from water	Removal of toxics from wastewater Genetically-engineered "bugs" for treatment of refractory material More efficient dewatering of oily sludges An economical way to remove dilute concentrations of organics from air

Table 7. Research Needs Continued

Category 3. Solid/hazardous waste handling, treatment, storage and disposal

University	Industry
Modeling of full scale incinerators	Solid & hazardous waste disposal
New contacting devices for toxic waste adsorption	Solids disposal/incineration
Role of ions in flames	Improved treatment of wastes
Chemical spill amelioration	Microbial treatment, in situ, of landfills
Resource & energy recovery from solid waste	Reclamation of disturbed land

Category 4. Waste recycling/reuse

University	Industry
None	Optimizing water recycle systems

Category 5. Manufacturing process changes to eliminate/reduce waste discnarges

University	Industry
Sulfur in coal characterization	None

Table 7. Research Needs Continued

Category 6. Economic impacts and cost analyses of pollution/pollution control

University	Industry
Technology cost impacts-economics	None

Category 7. Legal and policy research related to technological options

University	Industry
Devise practicable weighting system for site evaluation	Environmental risk assessment
Indices of degree of pollution (aquatic)	Simplifying permit applications and review

Category 8. Pollution control strategoes (e.g. in different media and different environments)

University	Industry
Other adsorption media for removal of organics from air or water	None

Category 9. Chemical and biological effects and interactions/ environmental modeling

University	Industry
Environmental simulation	Pollutant mobility and synergyism
Description of mass transfer kinetics in activated carbon	Permeation (molecular transport) through containment media
Kinetics of liquid phase oxidation of organics	
Kinetics of the gas-solid reactions of SO_2 or H_2S with other sorbents	
Better understanding of ozone reactions and reaction kinetics in water	
Biological effects of aerosols	

Category 9. Chemical and biological effects and interactions/environmental modeling (Continued)

University	Industry
Microbial aggregation phenomena	
Biodegradetion of abietic acids	
Ultimate fate of suspended solids	
Mechanism of optimal operation	
Toxic and beneficial effects of metals	
Toxicant-plant-animal interaction and patnways	
Numerical methods	
Water pollution modeling kinetics	

Category 10. Detection, measurement and analytical methods

University	Industry
Portable reflectometer	Body burden analysis and analytical techniques
Environmental monitoring	Landfill/impoundment liner leak detection with/leak repair w/o materials removal
Improved technique for in situ measurements of soil moisture	Develop reliable online process measurement techniques
GC analysis of pollutants	Non-disruptive, in situ particle size distributions on micro scale
Methods of analysis	
Dynamic analysis to control upsets	
Uncertainty analysis	
Cost analysis	
More analysis, less modeling	
Measurement and generation of free radicals	
Separation of particulates from fluid flow	
Instrumentation development	

Category 11. Global environmental problems such as the CO_2 greenhouse effect or acid rain

University	Industry
Atmospheric scavanging	Global environmental problems, e.g., acid rain
Mixing layer interactions	
Cloud chemistry processes	
Effects of pollutants on cloud microstructure	
Aircraft vortex simulation	

Table 7. Research Needs Continued

Category 12. Other

University	Industry
Thermodynamic data for chlorinated hydrocarbons and their radicals Better understanding of chemical equilibrium	None

Table 8. Summary of the Categories of Research and Design Needs as Perceived by Industrial and University Respondents

Category	Industrial						University						Total	
	Research			Design			Research			Design				
	1	2	3	1	2	3	1	2	3	1	2	3	No.	%
1. Pollution Source Identification/ Characterization	-	-	2	-	-	-	1	2	-	-	-	-	5	1.1
2. Water, Air, Thermal and Noise Pollution Control Technologies	11	10	6	9	10	8	18	17	13	25	11	9	147	33.0
3. Solid/Hazardous Waste Handling, Treatment, Storage & Disposal	1	2	3	5	3	6	5	6	5	2	6	5	49	11.0
4. Waste Recycling/Reuse	1	1	1	1	1	-	1	1	-	2	3	-	12	2.7
5. Manufacturing Process Changes to Eliminate/Reduce Waste Discharge	1	5	-	5	3	1	2	5	1	5	4	3	35	7.8
6. Economic Impacts and Cost Analyses of Pollution/Pollution Control	-	-	-	-	-	-	-	1	1	-	-	1	3	0.7
7. Legal and Policy Research Related to Technological Options	-	3	2	-	-	-	1	1	2	-	-	-	9	2.0
8. Pollution Control Strategies (e.g. diff. media and diff. environments	-	1	-	-	-	-	-	3	-	-	-	1	5	1.1
9. Chemical and Biological Effects and Interactions/Environmental Modeling	5	2	2	-	-	2	42	22	13	4	3	1	96	21.5
10. Detection, Measurement and Analytical Methods	1	1	4	-	1	-	16	16	12	6	7	2	66	14.8
11. Global Environmental Problems (CO_2 Greenhouse Effect or Acid Rain)	-	-	1	-	-	1	-	-	5	-	-	-	7	1.6
12. Other (physical properties, database, training)	-	-	-	2	2	-	4	1	2	1	-	-	12	2.7
													446	99.5

Table 9. Summary of Projects, Research Needs, and Design Needs Identified in 1984 Survey

Category*	Projects			Research Needs			Design Needs		
	Indus	Univ	Total	Indus	Univ	Total	Indus	Univ	Total
1	1	29	30	2	3	5	0	0	0
2	15	45	60	27	48	75	27	45	72
3	6	10	16	6	16	22	14	13	27
4	4	6	10	3	2	5	2	5	7
5	1	5	6	6	8	14	9	12	21
6	0	3	3	0	2	2	0	1	1
7	1	1	2	5	4	9	N/A	N/A	N/A
8	0	7	7	1	3	4	0	1	1
9	0	27	27	9	77	86	2	8	10
10	1	10	11	6	44	50	1	15	16
11	0	2	2	1	5	6	1	0	1
12	4	5	9	0	7	7	4	1	5
			183			285			161

*1. Pollution source identification/characterization
2. Water, air thermal, and noise pollution control technologies
3. Solid/hazardous waste handling, treatment, storage and disposal
4. Waste recycling/reuse
5. Manufacturing process changes to eliminate/reduce waste discharges
6. Economic impacts and cost analyses of pollution/pollution control
7. Legal and policy research related to technological options
8. Pollution control strategies (e.g. in different media and different environments)
9. Chemical and biological effects and interactions/ environmental modeling
10. Detection, measurement and analytical metnods
11. Global environmental problems such as the CO_2 greenhouse effect or acid rain
12. Other (phys. properties, databases, training)

Table 10. Comparison of 1973 Reported Funding Levels with 1984 Reported Funding Levels for University Projects

1973 University Project Category		Funding
I. Water Pollution	A - Measurement methods	$ 694,473
	B - Abatement & controls	2,914,257
	C - Legal and economic aspects	561,000
	D - Predictive modeling	2,908,011
	E - Effect on health and vegetation	952,449
	F - Misc. (surveys, training, materials studies)	2,113,300
II. Air Pollution	A - Measurement methods	1,000,700
	B - Abatement & controls	1,102,245
	C - Legal and economic aspects	11,000
	D - Predictive modeling	79,850
	E - Effect on health and vegetation	101,800
	F - Misc. (surveys, training, materials studies)	396,900
III. Solids Waste	A - Measurement methods	1,000
	B - Abatement & controls	501,270
	C - Legal and economic aspects	---
	D - Predictive modeling	---
	E - Effect on health and vegetation	81,500
	F - Misc. (surveys, training, materials studies)	274,000
IV. Noise Pollution		170,000
V. Graduate Training		351,000
VI. Air/Water/Solids Pollution Interaction		1,583,000
	TOTAL	$ 15,797,755

1984 University Project Category	Funding
1. Pollution source identification/ characterization	$ 3,168,345
2. Water, air, thermal, and noise pollution control technologies	3,844,142
3. Solid/hazardous waste handling, treatment, storage and disposal	1,014,961
4. Waste recycling/reuse	230,246
5. Manufacturing process changes to eliminate/reduce waste discharges	1,016,500
6. Economic impacts and cost analyses of pollution/pollution control	1,346,000
7. Legal and policy research related to technological options	18,000
8. Pollution control strategies (e.g. in different media and different environments	842,714
9. Chemical and biological effects and interactions/environmental modeling	3,227,231
10. Detection, measurement and analytical methods	1,052,598
11. Global environmental problems such as the CO_2 greenhouse effect or acid rain	---
12. Other (phys. properties, databases, training)	673,359
TOTAL	$ 16,434,096

APPENDIX

TABLE A-1. List of Universities Receiving the Questionnaire for the 1984 Survey of Research on Environmental Pollution---Its Sources, Fate, Effects and Control.

University
University of Akron
University of Alabama
University of Alberta
Arizona State University
University of Arizona
University of Arkansas
Auburn University
Brigham Young University
University of British Columbia
Brown University
Bucknell University
University of Calgary
University of California/Berkeley
University of California/Davis
University of California/LA
University of California/San Diego
University of California/Santa Barbara
California Institute of Technology
California State University/Long Beach
California State Poly. U./Pomona
Carnegie-Mellon University
Case Western Reserve University
Catholic University of America
University of Cincinnati
Clarkson College of Technology
Clemson University
Cleveland State University
University of Colorado
Colorado School of Mines
Colorado State University
Columbia University
University of Connecticut
The Cooper Union
Cornell University
Dartmouth College
University of Dayton
University of Delaware
University of Detroit
Drexel University
University of Florida

University
Florida Institute of Technology
Georgia Institute of Technology
University of Houston
Howard University
University of Idaho
University of Illinois
University of Illinois/Chicago
Illinois Institute of Technology
University of Iowa
Iowa St. Univ. of Sci. & Tech.
The John Hopkins University
University of Kansas
Kansas State University
University of Kentucky
Lafayette College
Lakehead University
Lamar University
Laval University
Lehigh University
Louisiana State University
Louisiana Tech University
Louisville Speed Scientific Sch.
University of Lowell
McGill University
McMaster University
McNeese State University
University of Maine
Manhatten College
University of Maryland
University of Massachusetts
Massachusetts Inst. of Tech.
University of Michigan
Michigan State University
Michigan Technological Univ.
University of Minnesota
University of Mississippi
Mississippi State University
University of Missouri/Columbia
University of Missouri/Rolla
Montana State University

Table A-1. Continued

University	University
University of Nebraska	University of Saskatchewan
University of Nevada/Reno	University de Sherbrooke
University of New Brunswick	University of South Carolina
University of New Hampshire	S. Dakota Sch. of Mines & Tech.
New Jersey Inst. of Tech.	University of South Florida
University of New Mexico	University of S. California
New Mexico State University	Univ. of Southwestern Louisiana
State Univ. of New York/Buffalo	Stanford University
The City C. of The City U. of New York	Stevens Inst. of Technology
Polytecnnic Inst. of New York/Brooklyn	Syracuse University
North Carolina State University/Raleigh	University of Tennessee
University of North Dakota	Tennessee Tech. University
Northeastern University	The University of Texas
Northwestern University	Texas A&I University
University of Notre Dame	Texas A&M University
Tech. University of Nova Scotia	Texas Tech University
Ohio State University	University of Toledo
Ohio University	University of Toronto
University of Oklahoma	Tri-State University
Oklahoma State University	Tufts University
Oregon State University	Tulane University
University of Ottawa	University of Tulsa
The Inst. of Paper Chemistry	University of Utah
University of Pennsylvania	Villanova University
Pennsylvania State University	University of Virginia
University of Pittsburgh	VPI & State Univ.
Polytechnic Inst. of Montreal/Ecole	University of Washington/Seattle
Pratt Institute	Washington State Univ./Pullman
Princeton University	Washington University/St. Louis
University of Puerto Rico	University of Waterloo
Purdue University	Wayne State University
Queen's University	University of Western Ontario
Rensselaer Polytechnic Inst.	West Virginia Inst. of Tech.
University of Rhode Island	West Virginia University
Rice University	Widner University
University of Rochester	University of Windsor
Rose-Hulman Inst. of Technology	University of Wisconsin/Madison
Royal Military C. of Canada	Worcester Polytechnic Institute
Rutgers-The State University	University of Wyoming
San Jose State University	Yale University
	Youngstown State University

Table A-2. List of Companies Receiving the Questionnaire for the 1984 Survey of Research on Environmental Pollution---Its Sources, Fate, Effects and Control

Industry	Industry
Aerojet-General Company	A. H. Robins Company, Inc.
Air Products & Chemicals, Inc.	Akzona, Incorporated
Allied Chemical Company	Aluminum Co. of America
Amax Metals	American Brands
American Can Company	American Cyanamid Company
American Home Products Corp.	Amer. Iron & Steel Inst.
American Petrofina	AMF Incorporated
Amoco	Armco, Inc.
ASARCO, Inc.	Ashland Oil Company
Atlantic Richfield	AT&T Technologies
BASF-Wyandotte Corporation	Babcock & Wilcox
The Badger Company Inc.	Badgers Engineers Inc.
Beatrice Foods	Bechtel Power Corp(Civ & Min)
Bendix Corporation	Bethlehem Steel Corporation
B. F. Goodrich Co.	Big Three Industries
Black & Veatch	The Boeing Company
Borden, Inc.	Borg-Warner Chemicals, Inc.
C.F. Braun & Co.	Bristol-Myers Company
Browning-Ferris Industries, Inc.	Brown & Root Inc.
Buffalo Color Corporation	Burlington Industries
Cabot Corporation	Calgon Corporation
Camp Dresser & McKee	Carus Chemical
CeCa Incorporated	Celanese Corporation
Champlin Petro Company	Champion Int'l Corporation
CHAS T. Main Incorporated	Chemagro Corporation
CH_2M Hill, Inc.	Chemed Corporation
Chevron Chemical Company	Ciba-Geigy
Cities Service Company	Continental Group
Colgate-Palmolive Company	Combustion Eng. Incorporated
Combustion Equipment Associates, Inc.	Conoco Incorporated
Continental Oil Company	Cosden Oil & Chemical Company
CPC International, Inc.	Crompton & Knowles
Culligan USA	Dames & Moore
Dana Corporation	Davy McKee Corporation
Diamond Shamrock Corporation	Dorr-Oliver Incorporated
Dow-Badische Company	Dow Chemical Company
Dow Corning Corporation	Dravo Corporation
Dundee Cement Company	Dupont-LouViers
Eastman Kodak Company	E. I. DuPont de Nemours & Co.
El Paso Natural Gas Company	Eli Lilly and Company

Table A-2. Continued

Industry	Industry
Emhart Corporation	Engelhardt Industries R & D
Esmark, Inc.	Essex Chemical Corporation
Ethyl Corporation	Exxon Chemical Company USA
Firestone Tire & Rubber Company	First Mississippi Corporation
Fluor Power Service Corporation	FMC Corporation
Ford Motor Company	Foster Wheeler Energy Corp.
Freeport-McMoran	GAF Corporation
Gas Research Institute	General Electric Company
General Mills, Inc.	Georgia-Pacific Company
Getty Oil Company	Getty Synfuels
Goodyear Tire and Rubber Co.	W. R. Grace & Co.
Great Lakes Chemical Corporation	Gulf Oil Chemicals Company
Gulf & Western Industries, Inc.	H. B. Fuller Company
Hercules Incorporated	Hoffmann-LaRoche
Honeywell, Inc.	Hooker Chemical
Hughes Aircraft Company	IBM Corporation
International Min. & Chem.	ICI-Americas Inc.
Inland Steel Company	International Flavors
International Paper	Int'l Telephone and Telegraph
Internorth Inc.	ITT Grinnell
IU Conversion Systems	Johnson & Johnson
J. P. Stevens & Co., Inc.	Kaiser Agric. Chem.
Kaiser Aluminum and Chemical Company	Kennecott Copper Company
The M.W. Kellogg Company	Kerr-McGee
Koppers Company Incorporated	Kraft, Inc.
Litton Industries	Liquid Air Corporation
Lockheed Aircraft Company	Loctite Corporation
L.T.V.	Lubrizol
Lurgi Corporation	McDonnell Douglas Corporation
Mallinckrodt Chemical Company	Marathon Petroleum
Martin Marietta Corporation	Matheson Gas Products
Merichem Company	Merck & Company
Michigan Chemical Company	Midland-Ross Corporation
Milliken & Company	Miles Lab
Millipore Corporation	Mine Safety Appliances Company
Minnesota Mining and Manufacturing	Mixing Equipment Company
Mobay Chemical Corporation	Mobil Oil Company (R. & D.)
Monsanto Company	Morton Thiokol
Nalco Chemical Company	National Renderers Association
National Distillers	Northwest Industries, Inc.

Table A-2. Continued

Industry	Industry
Occidental Chemical Corporation	Olin Corporation
Owens-Corning Fiberglas Corp./Illinois	Parke, Davis & Company
Ralph M. Parsons Corporation	Pennwalt, Inc.
Pennzoil Company	Petrolite Corporation
Pfizer Company	Philip A. Hunt Corporation
Philip Morris	Phillips Chemical Company
PPG Industries	Procter and Gamble Company
Quaker Oats Chem.	Ralston-Purina
Raysolv Incorporated	Reichhold Chemicals
Reynolds Metals	Richardson-Merrell, Inc.
R.J. Reynolds Industries	Rockwell Hanford Operations
Rockwell International	Rohm & Haas Company
Rollins, Inc.	Safety-Kleen Corporation
Schering-Plough Company	Shell Development Company
Shirco Incorporated	The Singer Company
SK & F Lab Company	Sohio Chemical Company
The Solvay AMER CORP	Smith, Kline and French
Squibb & Company	Stauffer Chemical Co.
St. Joe Lead Company	Standard Oil Company of Ohio
Stepan Chemical Company	Standard Oil of Indiana
Stearns Roger Inc.	Stone & Webster Eng.
St. Regis Paper Company	Sun Company, Inc.
Tenneco Chemicals, Inc.	Tennessee Eastman Company.
Research-Cottrell	Texaco
Texas Eastman Company	Texas Instrument, Inc.
TOSCO Corporation	Trane Thermal Company
TRW	Union Camp
Union Carbide and Chemical Co.	Union Oil Company
UOP Incorporated	U. S. Steel Company
UniRoyal, Inc.	United Technologies Corp.
UpJohn Company	U.S. Industrial Chemicals Co.
Vulcan Materials Company	Warner-Lambert Co.
Waste Management, Inc.	Westinghouse Electric Corp.
Westvaco Corporation	Weyerhaeuser Corporation
Winthrop Sterling	Williams Cos.
Witco Chemical Corporation	Zimpro Inc.

December 5, 1984

Dr. I. A. Jefcoat
Dept of Chemical
Engineering
University of Alabama
P. O. Box G
University, AL 35486

Dear :

AIChE's Research Committee and Environmental Division have requested that the Environmental Research Committee update the 1974 survey of information on research in colleges and universities on environmental pollution -- its sources, fate, effects, and control. This survey is partially supported by a grant from the U.S. Environmental Protection Agency. We would greatly appreciate your assistance in providing on Form A the requested information for your institution, and passing Form B to those who can provide project information.

There are literally hundreds of projects in progress in the general area of environmental engineering. There is, however, no central compilation of data on such research, development and design projects. Abstract services are not comprehensive and they normally make entries only after a project has been completed and the report issued. The AIChE survey would provide an up-to-date data source for reference by you and other researchers and would highlight areas where further research is needed. This Committee is also conducting a companion survey of environmental activities in industrial corporations, so the data base will be enriched and used by them as well. We will send all respondents a copy of our analysis of the R&D status and needs in this area. We also intend to publish the results in one of the AIChE Journals in order to more broadly disseminate the results of this effort. We will also be submitting a final report to the U.S. Environmental Protection Agency.

We hope that this survey will help academic researchers understand what industry perceives as the immediate and longer range environmental data needs. In a similar vein, industry will gain a greater awareness of the availability of data that may be needed to efficiently control pollution in manufacturing.

Enclosed with this letter are the following:

1. Form A - One form to be completed for each college or university. Please list on it the departments conducting research on environmental pollution and send the completed form to the above address.

2. Form B - One form to be completed for each project. Several forms are attached for convenience. Please distribute Form B to the appropriate departments and ask their department heads to have the forms completed and either returned to you or sent directly to the above address.

We recognize that it may be difficult to decide which projects to include in this survey. Our desire is to cover all projects on environmental pollution in Chemical Engineering Departments and projects in other Departments that either directly employ the "chemical engineering fundamentals," or directly relate to use of chemical engineering processes. To serve as a guide, we have divided project areas into the following categories:

1. Pollution source identification/characterization.

2. Water, air, solid, thermal and noise pollution control technologies.

3. Solid/hazardous waste handling, treatment, storage and disposal.

4. Waste recycling/reuse.

5. Manufacturing process changes to eliminate, reduce, or reuse environmentally undesirable waste discharges.

6. Economic impacts and cost analyses of pollution/pollution control.

7. Legal and policy research related to technological options.

8. Pollution control strategies (e.g., in different media and different environments).

9. Chemical and biological effects and interactions/environmental modeling.

10. Detection, measurement and analytic methods.

11. Global environmental problems such as the CO_2 Greenhouse Effect or Acid Rain.

12. Other (not primarily one of the above).

It would be very helpful if you could have these forms completed and returned to me by Feb. 1, 1985. Should you have questions, please write me at the above address or call me at (205) 348-6450. I apologize for placing this burden on you but hope you agree that this survey will be highly useful to industry (for research and design needs), to government (for providing resources where most needed) and to colleges and universities (for better planning of research).

Sincerely,

I. A. Jefcoat, Chairman
Environmental Research Committee

Enclosures

FORM A (One per Institution)

ENVIRONMENTAL RESEARCH COMMITTEE
AMERICAN INSTITUTE OF CHEMICAL ENGINEERS

1984 SURVEY OF RESEARCH ON ENVIRONMENTAL POLLUTION --
ITS SOURCES, FATE, EFFECTS AND CONTROL

NAME OF COLLEGE OR UNIVERSITY: _____

_____

ADDRESS: _____
(Street)

_____
(City) (State) (Zip Code)

DEPARTMENTS CONDUCTING RESEARCH ON ENVIRONMENTAL POLLUTION:

DEPARTMENT	DEPARTMENT HEAD	PHONE NO.

SUBMITTED BY:

NAME: _____

TITLE: _____

MAILING ADDRESS: _____

_____

TELEPHONE NUMBER: ( ) _____

Please return by Feb. 1, 1985, to: Dr. Irvin A. Jefcoat
Department of Chemical Engineering
The University of Alabama
P.O. Box G
University, AL 35486

If you have any questions, please call (205)348-6450

FORM B (One per Project)

ENVIRONMENTAL RESEARCH COMMITTEE
AMERICAN INSTITUTE OF CHEMICAL ENGINEERS

1984 SURVEY OF RESEARCH ON ENVIRONMENTAL POLLUTION --
ITS SOURCES, FATE, EFFECTS AND CONTROL

DESCRIPTIVE PROJECT TITLE: _____

_____

MAJOR
OBJECTIVE(S): _____

_____

_____

PRINCIPAL INVESTIGATOR: _____
(Name) (Title)

_____
(Department) (Area Code/Phone No.)

INSTITUTION: _____
(College/University) (City/State/Zip)

CO-PRINCIPAL INVESTIGATOR OR ASSISTANT _____
(Name) (Title)

_____
(Address and Phone No., if different from above.)

For sections A, B, and C please enter "P" for primary category and "S" for other, secondary categories which may apply.

A. PROJECT CATEGORY:

Pollution source identification/ characterization ____
Water, air, thermal and noise pollution control technologies ____
Solid/hazardous waste handling, treatment, storage and disposal ____
Waste recycling/reuse ____
Manufacturing process changes to eliminate/reduce waste discharges ____
Economic impacts and cost analyses of pollution/pollution control ____
Legal and policy research related to technological options ____
Pollution control strategies (e.g., in different media and different environments) ____
Chemical and biological effects and interactions/environmental modeling ____
Detection, measurement and analytical methods ____
Other (describe) _____
_____
_____

Form B, page 2

B. SCALE/TYPE OF WORK:

Laboratory	____	Field	____	Other (describe)	
Pilot	____	Theoretical Analysis	____	_____	
Full	____	Computer Simulation	____	_____	

C. CHEMICAL ENGINEERING PRINCIPLES INVOLVED (check all that apply):

Mass Transfer	____	Thermodynamics	____
Fluid Flow	____	Heat Transfer	____
Particle Dynamics	____	Separations	____
Reaction Kinetics	____	Other _____	
		_____	

RESEARCH NEEDS:

Please list the three (3) research topics that you think are the most important for making advances in <u>your</u> area(s) of research on environmental pollution:

1. _____(most important)
2. _____
3. _____

DESIGN NEEDS:

Please list the three (3) process design needs that you think would yield the greatest gains in environmental pollution control:

1. _____(most important)
2. _____
3. _____

PROJECT INFORMATION:

Start Date: _____
Completion Date: _____
Work Years: _____

Funding Sources: Univ.: $_____
Industry: $_____
Gov't.: $_____ _____ (Agency)
Other: $_____ _____ (Source)

Funding Uses: Manpower: $_____
Equipment: $_____
Other (Specify): $_____ : _____
$_____ : _____
$_____ : _____

Total Funding: $_____

Form B, page 3

STATUS OF PROJECT: _____

_____

_____

(Please attach a bibliography of publications published/expected from this project)

SUBMITTED BY: _____ _____
(Name) (Date)

_____
(Title)

Please complete this questionaire by Feb. 1, 1985, and return to your department head or mail it directly to:

Dr. Irvin A. Jefcoat
Department of Chemical Engineering
The University of Alabama
P.O. Box G
University, AL 35486

If you have any questions, call (205)348-6450.

December 5, 1984

Dr. I. A. Jefcoat
Dept of Chemical
Engineering
University of Alabama
P. O. Box G
University, AL 35486

Dear :

AIChE's Research Committee and Environmental Division have requested that the Environmental Research Committee update the 1974 survey of information on research in colleges and universities on environmental pollution -- its sources, fate, effects, and control. This survey is partially supported by a grant from the U.S. Environmental Protection Agency. This year we are expanding the survey to include industrial research and design needs. We would greatly appreciate your assistance in providing on Form A the requested information for your company, and passing Form B to those who can provide project information.

There are literally hundreds of projects in progress in the general area of environmental engineering. There is, however, no central compilation of data on such research, development and design projects. Abstract services are not comprehensive and they normally make entries only after a project has been completed and the report issued. The AIChE survey would provide an up-to-date data source for reference by you and other researchers and would highlight areas for further research and design needs. We will send all respondents a copy of our analysis of the R&D status and needs in this area. We also intend to publish the results in one of the AIChE Journals in order to more broadly disseminate the results of this effort. We will also be submitting a final report to the U.S. Environmental Protection Agency.

We hope that this survey will help academic researchers understand what industry perceives as the immediate and longer range environmental data needs. In a similar vein, industry will gain a greater awareness of the availability of data that may be needed to efficiently control pollution in manufacturing.

Enclosed with this letter are the following:

1. Form A - One form to be completed for each company. Please list on it the departments conducting research on environmental pollution and send the completed form to the above address.

2. Form B - One form to be completed for each project. Several forms are attached for convenience. Please distribute Form B to the appropriate departments and ask their department heads to have the forms completed and either returned to you or sent directly to the above address.

We recognize that it may be difficult to decide which projects to include in this survey. Our desire is to cover all projects on environmental pollution that either directly employ "chemical engineering fundamentals," or directly relate to the use of chemical engineering processes. To serve as a guide, we have divided project areas into the following categories:

1. Pollution source identification/characterization.

2. Water, air, solid, thermal and noise pollution control technologies.

3. Solid/hazardous waste handling, treatment, storage and disposal.

4. Waste recycling/reuse.

5. Manufacturing process changes to eliminate, reduce, or reuse environmentally undesirable waste discharges.

6. Economic impacts and cost analyses of pollution/pollution control.

7. Legal and policy research related to technological options.

8. Pollution control strategies (e.g., in different media and different environments).

9. Chemical and biological effects and interactions/environmental modeling.

10. Detection, measurement and analytic methods.

11. Global environmental problems such as the CO_2 Greenhouse Effect or Acid Rain.

12. Other (not primarily one of the above).

It would be very helpful if you could have these forms completed and returned to me by Feb. 1, 1985. Should you have questions, please write me at the above address or call me at (205) 348-6450. I apologize for placing this burden on you but hope you agree that this survey will be highly useful to industry (for research and design needs), to government (for providing resources where most needed) and to colleges and universities (for better planning of research).

Sincerely,

I. A. Jefcoat, Chairman
Environmental Research Committee

Enclosures

FORM A (One per Company)

ENVIRONMENTAL RESEARCH COMMITTEE
AMERICAN INSTITUTE OF CHEMICAL ENGINEERS

1984 SURVEY OF RESEARCH ON ENVIRONMENTAL POLLUTION --
ITS SOURCES, FATE, EFFECTS AND CONTROL

TO BE COMPLETED BY ENVIRONMENTAL COORDINATOR

NAME OF COMPANY: _____

_____

ADDRESS: _____
(Street)

_____
(City) (State) (Zip Code)

DEPARTMENTS/GROUPS CONDUCTING RESEARCH ON ENVIRONMENTAL POLLUTION:

DEPARTMENT/GROUP	DEPARTMENT HEAD	PHONE NO.

SUBMITTED BY:

NAME: _____

TITLE: _____

MAILING ADDRESS: _____

_____

TELEPHONE NUMBER: ( ) _____

Please Return By Feb. 1, 1985, To: Dr. Irvin A. Jefcoat
Dept. of Chemical Engineering
The University of Alabama
P.O. Box G
University, AL 35486

If you have any questions, please call (205)348-6450

FORM B (One per Project)

ENVIRONMENTAL RESEARCH COMMITTEE
AMERICAN INSTITUTE OF CHEMICAL ENGINEERS

1984 SURVEY OF RESEARCH ON ENVIRONMENTAL POLLUTION --
ITS SOURCES, FATE, EFFECTS AND CONTROL

DESCRIPTIVE PROJECT TITLE: _____

_____

MAJOR
OBJECTIVE(S): _____

_____

_____

PRINCIPAL INVESTIGATOR: _____
(Name) (Title)

_____
(Department) (Area Code/Phone No.)

COMPANY: _____
(City/State/Zip)

CO-PRINCIPAL INVESTIGATOR OR ASSISTANT _____
(Name) (Title)

_____
(Address and Phone No., if different from above.)

For sections A, B, and C please enter "P" for primary category and "S" for other, secondary categories which may apply.

A. PROJECT CATEGORY:

Pollution source identification/ characterization ____
Water, air, thermal and noise pollution control technologies ____
Solid/hazardous waste handling, treatment, storage and disposal ____
Waste recycling/reuse ____
Manufacturing process changes to eliminate/reduce waste discharges ____
Other (describe) _____
_____
_____

Economic impacts and cost analyses of pollution/pollution control ____
Legal and policy research related to technological options ____
Pollution control strategies (e.g., in different media and different environments) ____
Chemical and biological effects and interactions/environmental modeling ____
Detection, measurement and analytical methods ____
Global environmental problems such as the CO_2 greenhouse effect or acid rain ____

Form B (Project), page 2

B. SCALE/TYPE OF WORK:

Laboratory	____	Field	____	Other (describe)	_____
Pilot	____	Theoretical Analysis	____		_____
Full	____	Computer Simulation	____		_____

C. CHEMICAL ENGINEERING PRINCIPLES INVOLVED (check all that apply):

Mass Transfer	____	Thermodynamics	____
Fluid Flow	____	Heat Transfer	____
Particle Dynamics	____	Separations	____
Reaction Kinetics	____	Other	_____
			_____

PROJECT INFORMATION:

Start Date: _____
Completion Date: _____
Work Years: _____

Funding Sources: Industry: $_____
Gov't.: $_____ _____ (Agency)
Other: $_____ _____ (Source)

Funding Uses: Manpower: $_____
Equipment: $_____
Other (specify): $_____ _____
$_____ _____
$_____ _____

Total Funding: $_____

STATUS OF PROJECT: _____

_____

_____

(Please attach a bibliography of publications published/expected from this project)

SUBMITTED BY: _____ _____
(Name) (Date)

_____
(Title)

_____
(Phone no., if different from above)

Please complete this questionaire by Feb. 1, 1985, and return to your department head or mail it directly to:

Dr. Irvin A. Jefcoat
Department of Chemical Engineering
The University of Alabama
P.O. Box G
University, AL 35486

If you have any questions, please call (205)348-6450.

FORM B (General)

ENVIRONMENTAL RESEARCH COMMITTEE
AMERICAN INSTITUTE OF CHEMICAL ENGINEERS

1984 SURVEY OF RESEARCH ON ENVIRONMENTAL POLLUTION --
ITS SOURCES, FATE, EFFECTS AND CONTROL
INDUSTRIAL SECTOR

1. Please list the three (3) process design needs that you think would yield the greatest gains in environmental pollution control.

   1. _____(most important)

   2. _____

   3. _____

2. Please list the three (3) research topics that you think are most important for making advances in environmental pollution control

   1. _____ (most important)

   2. _____

   3. _____

3. From your answer to question 2, please describe the research objectives that you would like to see accomplished for the most important research need.

4. Is your organization sponsoring or conducting any research related to environmental subjects?

   _____yes _____no

5. If yes, can you provide us with the information requested on Form B (Project), attached, for at least some of this work?

   _____yes, information attached _____no, the work is proprietary

   _____no, company policy does not allow release

   _____yes, with approval of management, the results will be forthcoming

Please return this form by Feb. 1, 1985, to:

Dr. Irvin A. Jefcoat
Department of Chemical Engineering
The University of Alabama
P.O. Box G
University, AL 35486

If you have any questions, please call (205)348-6450.

6. Please specify how effort by percentages should be allocated among these categories of research. Please feel free to add as many categories as desired.

	TOTAL EFFORT	EFFORT OF ChE's
a. health effect of pollutants	_____%	_____%
b. environmental impacts	_____%	_____%
c. mechanisms of pollutant formation	_____%	_____%
d. environmental transport and fate of pollutants	_____%	_____%
e. measurement of pollutants released from industrial processes	_____%	_____%
f. research on measurement/analytical methodology	_____%	_____%
g. pollutant control technology	_____%	_____%
h. environmental reclamation and/or correction of past improper practices	_____%	_____%
i. _____	_____%	_____%
j _____	_____%	_____%

7. Most of the above categories can be split by pollutant medium. Please indicate how you feel the overall effort should be split in this manner.

a. air (Clean Air Act)	_____%
b. surface water (Clean Water Act)	_____%
c. groundwater	_____%
d. drinking water cleanup (SDWA)	_____%
e. solid waste (RCRA, CERCLA)	_____%
f. intermedia (i.e., interaction between air and water pollution)	_____%